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Study on the Electromagnetic-Protective Specialty of Carbon Nanotubes

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Abstract. Based on electromagnetic-wave penetration method, the electromagnetic wave attenuation abilities of six kinds of CNTs were studied in experiment at 12~18 GHz, whose diameter at 30 nm, 60 nm, 100 nm and length at 2 μm and 15 μm. Such results are concluded from the experiment. With the same diameter 30 nm, the absorption ability of CNTs with the length 15 μm is better than which with the length 2 μm; With the same diameter 60 nm, the absorption ability of CNTs with the length 2 μm is better than which with the length 15 μm; With the same diameter 100 nm, electromagnetic attenuation ability of CNTs with the length 15 μm is better than which with the length 2 μm. Electromagnetic attenuation ability order of CNTs with the same length is that Φ60 nm > Φ100 nm > Φ30 nm. On the absorption ability, the best is CNTs with Φ60 nm × 2 μm, and the worst is CNTs with Φ30 nm × 2 μm. At 12~18 GHz, the absorption orders of the six kinds of CNTs is that Φ60 nm × 2 μm > Φ 60 nm × 15 μm > Φ100 nm × 15 μm >Φ100 nm × 2 μm > Φ 30 nm × 15 μm > Φ 30 nm × 2 μm.

1 Introduction

Carbon nanotubes (CNTs) were firstly discovered by Iijima of NEC Co. in 1991[1]. CNTs have special absorption ability for the neutrons and electromagnetic wave, also the high energy particles X rays and γrays. While, there is only a few researches on these abilities presently. Especially there are no research published papers on the attenuations for CNTs with different structures [2].

The electromagnetic wave attenuation abilities of six kinds of CNTs with different diameters were studied in experiment at 12~18 GHz in this paper. The reasons for their different absorption, such as the structure factors diameter and length, were analyzed.

2 Experimental materials and methods

The electromagnetic-wave penetration method was used to test the attenuation of CNTs, just as the Fig.1

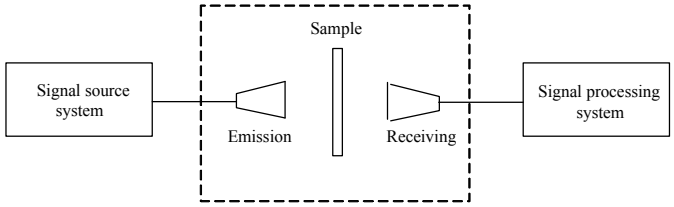


Fig.1 The experiment system of electromagnetic-wave attenuation of CNTs

The 6 kinds of CNTs were made by catalysis split methods with the catalyst Co and Mo. The purity of the 6 kinds of CNTs ≥95 wt% , and ash content ≤0.2 wt%, and unformed C＜3 wt%, and the specific surface is about 40～300 m^2/g. They are called 100L, 100S, 60L, 60S, 30L and 30S, and the parameters of the samples are just as the Table 1.

The 6 kinds of CNTs were coated on the tape（27 cm×27 cm）, and they are fixed on the center of foam plate (50 cm×50 cm). Three blocks of samples is made for each kind of CNTs.

Table 1 Parameters of carbon nanotubes sample

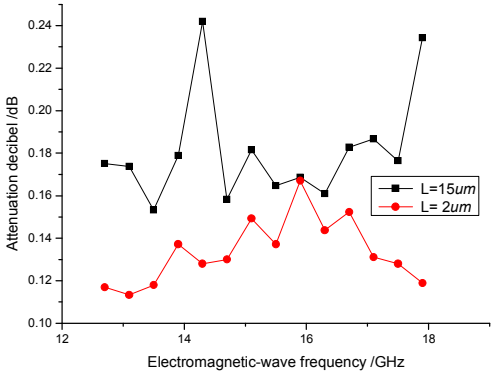
CNTs sample	Diameter /**nm**	Length /μ**m**
100L	60~100	5～15
100S	60~100	1~2
60L	40~60	5～15
60S	40~60	1~2
30L	10~30	5～15
30S	10~30	1~2

3 Results and discussion

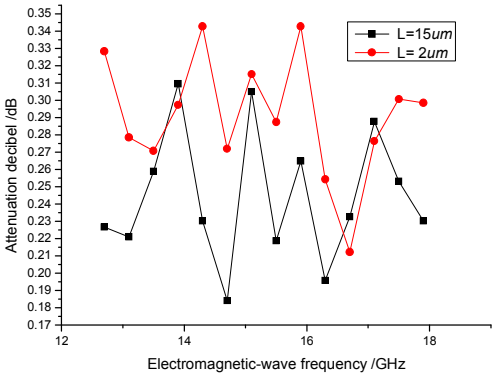
The average attenuation of each sample is calculated, using the method that the average attenuation decibel is divided by mean density. So the parameters effecting the attenuation can be analyzed, such as length and diameter. The attenuation curve of CNTs with same diameter and different length is showed in Fig.2. The attenuation curve of CNTs with same length and different diameter is showed in Fig.3.

3.1 Affecting factor length:

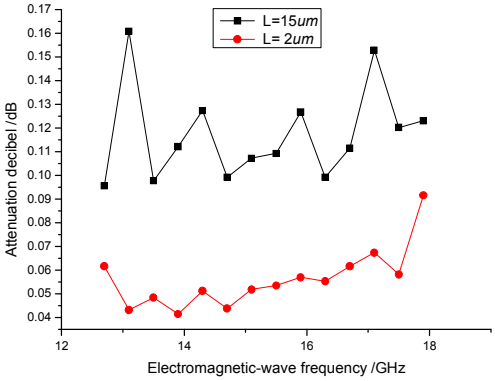
Fig.2 shows the attenuation curve of CNTs with same diameter and different length. For the same diameter 100 nm, the attenuation curve of CNTs with length 5～15 μm is obviously above which with length 1～2 μm. It means that for the same diameter 100nm the attenuation ability of CNTs with length 5～15 μm is better than which with the length 1～2 μm. For the same diameter 60nm the attenuation ability of CNTs with length 1～2 μm is better than which with the length 5～15 μm. The attenuation ability for the CNTs with diameter 30 nm is the reverse of which with diameter 60nm. It means that the attenuation ability of CNTs with length 5～15 μm is better than which with the length 1～2 μm.



（a）CNTs with D=100 nm



（b）CNTs with D=60 nm

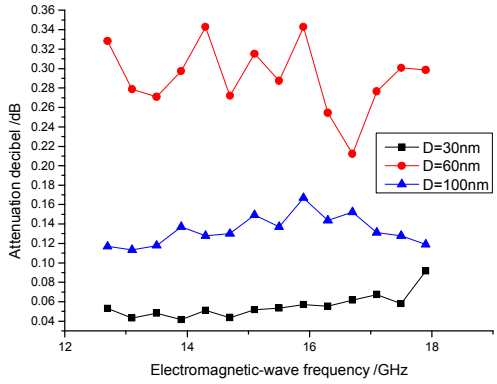


（c）CNTs with D=30 nm

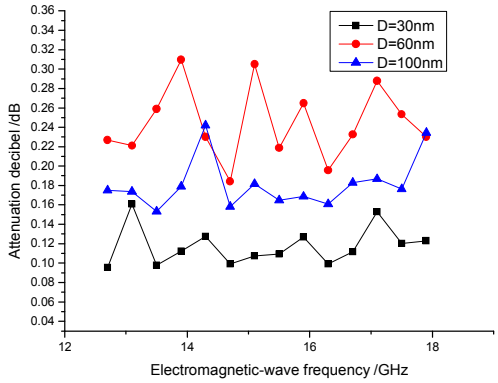
Fig.2 Attenuation figure of CNTs with equal diameter and different lengths

3.2 Affecting factor diameter:

Fig.3 shows the attenuation curve of CNTs with same length and different diameter. For the same length, the attenuation curves express the consistency regular. It is that the curve of CNTs with diameter 60 nm is above of which with the diameters 100 nm and 30 nm, and the curve of CNTs with diameter 100 nm is above of which with the diameter 30 nm. The results show that the CNTs diameter is an important effecting factor for electromagnetic attenuation. Such conclusion is induced. Electromagnetic attenuation ability order of CNTs with the same length is that Φ60 nm > Φ100 nm > Φ30 nm.



（a）CNTs with L=2 μm



（b）CNTs with L=15 μm

Fig.3 Attenuation figure of CNTs with equal length and different diameter

3.3 Discussion:

There are several reasons for high attenuation of CNTs. The most important is the nanometer specialty for the CNTs. The CNTs have the unique net structure, the high specific surface area(the samples experimented with surface area 300 $m^2 \cdot g^{-1}$), the quantum dimension effect, the small scale effects, the attenuation scattering and polarization of the π electron located at the outer layer of C atom.

The 60S is the best for attenuation, and the worst is the 30S. The reason is probably that the CNTs with diameter 60 nm and length 1～2 μm express the apparent nano-character of small slenderness ratio. For these characters, its multi-aperture net structure makes the multiple scattering for rays and also the dipole is easily formed, which deflects orientation at the electromagnetic wave consuming the energy. While the 30S have small diameter, this determines the minimum attenuation ability. At 12~18 GHz, the absorption orders of the six kinds of CNTs is that Φ 60 nm × 2 μm > Φ 60 nm × 15 μm > Φ 100 nm × 15 μm >Φ 100 nm × 2 μm > Φ 30 nm × 15 μm > Φ 30 nm × 2 μm. Briefly the most important factor affecting attenuation for CNTS is the length, diameter, density of sample, and its special structure, etc.

The CNTs composites also have good shielding properties for X rays and γ rays. The CNTs and nano-$PbSO_4$ can be composited to new neutron shielding material. The boron carbide nanotube is a kind of new radio-protective material for X rays, γ rays and neutrons. CNTs have extraordinary attenuation abilities for rays and neutrons, for its special properties, such as the mall-scale effects, surface and boundary layer effects, quantum dimension affects and the large specific surface area, etc. All these properties determine the larger reaction cross-section for high-energy neutron, X rays, and γ rays. So the CNTs composites have larger attenuation effects for high-energy rays. So more research works are needed to be done presently.

4 Conclusions

Based on electromagnetic-wave penetration method, the electromagnetic wave attenuation abilities of six kinds of CNTs were studied in experiment at 12~18 GHz, whose diameter at 30 nm, 60 nm, 100 nm and length at 2 μm and 15 μm. Such results are concluded from the experiment. With the same diameter 30 nm, the absorption ability of CNTs with the length 15 μm is better than which with the length 2 μm; With the same diameter 60 nm, the absorption ability of CNTs with the length 2 μm is better than which with the length 15 μm; With the same diameter 100 nm, electromagnetic attenuation ability of CNTs with the length 15 μm is better than which with the length 2 μm. Electromagnetic attenuation ability order of CNTs with the same length is that Φ60 nm > Φ100 nm > Φ30 nm. On the absorption ability, the best is CNTs with Φ60 nm × 2 μm, and the worst is CNTs with Φ30 nm × 2 μm. At 12~18 GHz, the absorption orders of the six kinds of CNTs is that Φ60 nm × 2 μm > Φ 60 nm × 15 μm > Φ100 nm × 15 μm >Φ100 nm × 2 μm > Φ 30 nm × 15 μm > Φ 30 nm × 2 μm.

The CNTs composites have special attenuation ability for rays and neutrons. They can be made to high-intensity, light-weight, radio-resistance structured integral function material, so that they can be used as skin material of rocket. Also, they can be made into light-density, light-weight fabric, easily to be sworn for person. The research on the CNTs has a prospective significance in radio-protective field.

References

[1] Iijima S., 1991, “Helical microtubules of graphitic carbon”, *Nature*, vol.**354**, pp. 56-58.

[2] CHEN Rensong., HE Bin., WANG Hongxia., 2007, “Experimental studies on electromagnetic-wave attenuation of carbon nanotubes at 8～12GHz”, *Acta Materiae Compositae Sinica*, vol.**24**(3), pp.126-130.